CLAIMS

What is claimed is:

1. A wet-brush electrode that facilitates electrode-tissue contact in target tissue having contoured surfaces, the wet-brush electrode comprising

a plurality of flexible filaments adapted to transfer ablative energy to target tissue, said flexible filaments defining interstitial spaces among said plurality of filaments, wherein said interstitial spaces are adapted to carry conductive fluid;

a primary conductor operatively connected to, and adapted to transfer ablative energy to, said plurality of flexible filaments; and

a fluid-delivery means adapted to deliver conductive fluid to said interstitial spaces.

2. A catheter for tissue ablation, the catheter comprising

an outer sheath having a distal end;

a brush electrode, said brush electrode comprising

a plurality of flexible filaments adapted to transfer ablative energy to target tissue during lesion formation, wherein said flexible filaments extend from said distal end of said outer sheath; and

a primary conductor in electrical contact with said plurality of filaments; and

attachment means for securing said brush electrode to said distal end of said outer sheath.

3. The catheter of claim 2, wherein said attachment means comprises at least one suture, and wherein a section of shrink tube covers said at least one suture.

4. The catheter of claim 2, wherein each filament comprising said plurality of flexible filaments has a distal end, and wherein at least some of said flexible filaments gradually taper towards said distal ends of said at least some of said flexible filaments.

5. The catheter of claim 2, wherein each filament comprising said plurality of flexible filaments has a distal end, and wherein at least some of said flexible filaments have nonconductive tips at said distal ends of said at least some of said flexible filaments.

6. The catheter of claim 2, wherein said plurality of flexible filaments of said brush electrode comprises conductive filaments and nonconductive filaments.

7. The catheter of claim 6, wherein said nonconductive filaments are longer than said conductive filaments.

8. The catheter of claim 2, wherein said brush electrode further comprises a secondary lead extending to, and becoming embedded within, said plurality of flexible filaments.

9. The catheter of claim 8, wherein said brush electrode further comprises a device operatively connected to said secondary lead and embedded among said plurality of flexible filaments.

10. The catheter of claim 9, wherein said embedded device is selected from the group consisting of a thermocouple, a pressure sensor, and an ultrasound sensor.

11. The catheter of claim 2, wherein said outer sheath further comprises a concentric ring of sub-channels around a main channel, and wherein at least a portion of said flexible filaments resides in said main channel.

12. The catheter of claim 2, wherein said brush electrode comprises an exposed portion and an embedded portion, and wherein said outer sheath is porous adjacent to said exposed portion of said brush electrode.

13. The catheter of claim 2, wherein said brush electrode comprises an exposed portion and an embedded portion, and wherein said outer sheath has a threaded outer surface adjacent to said exposed portion of said brush electrode.

14. The catheter of claim 13 further comprising a covering, wherein said covering surrounds said threaded outer surface of said outer sheath, thereby creating a helical flow channel between said threaded outer surface and said covering.

15. The catheter of claim 2, wherein said brush electrode comprises an exposed portion and an embedded portion, and wherein said outer sheath has a grooved outer surface adjacent to said exposed portion of said brush electrode.

16. The catheter of claim 15 further comprising a covering that surrounds said grooved outer surface of said outer sheath, thereby creating at least one longitudinally-extending flow channel between said grooved outer surface and said covering.

17. The catheter of claim 2, wherein said primary conductor makes electrical contact with said plurality of flexible filaments via an energy transfer coil surrounding at least a contact portion of said brush electrode.

18. The catheter of claim 2, wherein said primary conductor makes electrical contact with said plurality of flexible filaments via an energy transfer mesh surrounding at least a contact portion of said brush electrode.

19. The catheter of claim 2, wherein each filament comprising said plurality of flexible filaments has a distal end, and wherein at least some of said filaments comprising said plurality of flexible filaments are hollow at their distal ends.

20. The catheter of claim 2, wherein each filament comprising said plurality of flexible filaments has a distal end, and wherein at least some of said filaments comprising said plurality of flexible filaments are porous at their distal ends.

21. A catheter for ablating tissue inside a human body, the catheter comprising

an outer sheath having a distal end;

a conforming electrode adapted to apply ablative energy to target tissue, said conforming electrode comprising an embedded portion and an exposed portion, wherein said exposed portion has a distal end, wherein a working surface is present at said distal end of said exposed portion, and wherein said exposed portion extends from said distal end of said outer sheath; and

a primary conductor in direct electrical contact with said conforming electrode and adapted to carry ablative energy from an energy source to said conforming electrode.

22. The catheter of claim 21 further comprising attachment means for securing said conforming electrode to said distal end of said outer sheath.

23. The catheter of claim 21, wherein said conforming electrode comprises a brush electrode having a plurality of flexible filaments.

24. The catheter of claim 23, wherein each filament of said plurality of flexible filaments has a distal end, and wherein said distal ends of said plurality of flexible filaments comprise said working surface of said exposed portion.

25. The catheter of claim 24, wherein said distal ends of said filaments are trimmed to create a shape for said working surface of said exposed portion of said brush electrode selected from the group consisting of a relatively flat surface, a blade, a point, a trough, a dome, and a channel.

26. The catheter of claim 24, wherein said plurality of flexible filaments of said brush electrode comprises conductive filaments and nonconductive filaments, and wherein said distal ends of said conductive filaments are not flush with said distal ends of said nonconductive filaments at said working surface of said exposed portion.

27. The catheter of claim 26, wherein said nonconductive filaments are longer than said conductive filaments and are thereby adapted to create a standoff distance between the tissue and said conductive filaments when said working surface of said exposed portion is placed against the tissue.

28. The catheter of claim 23, wherein said plurality of flexible filaments comprises nonconductive materials and conductive materials.

29. The catheter of claim 28, wherein said filaments are selected from the group consisting of acrylic fibers, metal fibers, metal plated fibers, conductively-coated fibers, and carbon-compound fibers.

30. The catheter of claim 28, wherein said flexible filaments comprising conductive materials are in electrical contact with each other.

31. The catheter of claim 23, wherein said primary conductor comprises insulated copper wire having an uninsulated portion in electrical contact with said brush electrode.

32. The catheter of claim 31, wherein said uninsulated portion of said primary conductor is looped around said filaments comprising said brush electrode at a connection point.

33. The catheter of claim 23 further comprising a mechanical interface for making electrical contact between said flexible filaments of said brush electrode and said primary conductor.

34. The catheter of claim 33, wherein said mechanical interface is selected from the group consisting of a wire loop, an energy transfer coil, an energy transfer mesh, and an energy transfer wrap.

35. The catheter of claim 33, wherein said outer sheath has an inner surface, and wherein said mechanical interface is a wire loop anchored to said inner surface of said outer sheath.

36. The catheter of claim 23, wherein said catheter further comprises a secondary lead, and wherein said secondary lead has a distal end embedded with said flexible filaments.

37. The catheter of claim 36, wherein said secondary lead is operatively connected to a device embedded in said brush electrode.

38. The catheter of claim 37, wherein said device is selected from the group consisting of a thermal sensor, an ultrasound sensor, and a pressure sensor.

39. The catheter of claim 23, wherein said brush electrode comprises a bundle of conductive filaments and nonconductive filaments that are folded and inserted at least partly into said distal end of said outer sheath

40. The catheter of claim 23, wherein said plurality of flexible filaments comprises conductive filaments, and wherein said conductive filaments have radially-varying conductivity.

41. The catheter of claim 40, wherein said conductive filaments have longitudinal axes, and wherein said radially-varying conductivity is greatest adjacent to said longitudinal axes.

42. The catheter of claim 23, wherein said plurality of flexible filaments comprises conductive filaments having longitudinal axes, and wherein said conductive filaments have varying conductivity along said longitudinal axes.

43. The catheter of claim 42, wherein said filaments are coated with materials having different electrical conductivity at different locations along said filaments.

44. The catheter of claim 42, wherein said conductivity varies continuously.

45. The catheter of claim 44, wherein said brush electrode comprises tapered filaments.

46. The catheter of claim 45, wherein at said distal end of said outer sheath, said filaments have larger cross-sectional areas than said filaments have at said distal ends of said filaments.

47. The catheter of claim 46, wherein said outer sheath further comprises a lumen adapted to carry a conductive fluid from a fluid supply to interstitial gaps among said flexible filaments, and wherein said conductivity of said flexible filaments is adapted to match a conductivity of said conductive fluid at said distal ends of said filaments.

48. The catheter of claim 42, wherein said conductivity varies discontinuously.

49. The catheter of claim 48, wherein each filament of said plurality of flexible filaments has a distal end, and wherein said conductive filaments further comprise nonconductive tips at said distal ends of said filaments.

50. The catheter of claim 23, wherein said outer sheath further comprises a circumferential ring of sub-channels around a main channel, and wherein said plurality of flexible filaments extends in said main channel.

51. The catheter of claim 50, wherein said sub-channels are adapted to carry fluid.

52. The catheter of claim 23, wherein said outer sheath surrounding said plurality of flexible filaments is porous adjacent to said exposed portion of said brush electrode.

53. The catheter of claim 23, wherein a threaded sheath surrounds said plurality of flexible filaments, said threaded sheath having an outer surface and a spiral ridge on said outer surface.

54. The catheter of claim 53, wherein said catheter further comprise a covering around at least a portion of said threaded sheath, thereby defining a helical flow channel between said threaded sheath and said covering, wherein said helical flow channel is adapted to deliver fluid to tissue adjacent to said brush electrode.

55. The catheter of claim 23, wherein a grooved sheath surrounds said plurality of flexible filaments of said brush electrode, said grooved sheath having an outer surface and at least one longitudinally-extending groove formed on said outer surface of said grooved sheath.

56. The catheter of claim 55, wherein said catheter further comprise a covering around at least a portion of said grooved sheath, thereby defining at least one longitudinally-extending flow channel between said grooved sheath and said covering, wherein said longitudinally-extending flow channel is adapted to deliver fluid to tissue adjacent to said brush electrode.

57. The catheter of claim 21, wherein said outer sheath is formed from sections of different material.

58. The catheter of claim 21, wherein said outer sheath provides mechanical support for said plurality of flexible filaments and provides electrical shielding for said plurality of flexible filaments.

59. The catheter of claim 21, wherein said outer sheath further comprises a lumen adapted to carry conductive fluid from a fluid source to said brush electrode.

60. The catheter of claim 59, wherein said lumen has a configuration selected from the group consisting of a single, embedded channel; a plurality of sub-channels; a helical channel; and at least one longitudinally-extending groove.

61. The catheter of claim 59, wherein said primary conductor extends within said lumen of said catheter.

62. A catheter for tissue ablation, the catheter comprising

an outer sheath having a distal end;

a shielded-tip brush electrode at said distal end of said outer sheath, said shielded-tip brush electrode comprising

a bundle of filaments adapted to transfer ablative energy to target tissue during the formation of a lesion, wherein said bundle of filaments extend from said distal end of said outer sheath, and wherein said bundle of filaments has an outer surface; and

a primary conductor having an uninsulated portion, wherein said uninsulated portion is in electrical contact with said plurality of filaments; and

attachment means for securing said shielded-tip brush electrode to said distal end of said outer sheath.

63. The catheter of claim 62, wherein said uninsulated portion of said primary conductor is looped around said outer surface of said bundle of filaments comprising said shielded-tip brush electrode.

64. The catheter of claim 63 further comprising an inner sheath having a distal end, wherein said attachment means comprises a mechanical interface supporting said bundle of filaments adjacent to said distal end of said inner sheath, and wherein said uninsulated portion of said primary conductor passes through said mechanical interface before looping around said outer surface of said bundle of filaments.

65. A catheter, the catheter comprising

an outer sheath having a distal end;

an inner sheath having a distal end;

an annular channel defined between said outer sheath and said inner sheath, wherein said annular channel is adapted to carry fluid;

a mechanical interface supported at least in part by said distal end of said inner sheath;

a flexible electrode adapted to apply ablative energy to target tissue, wherein said flexible electrode is supported by said mechanical interface, wherein said flexible electrode comprises an embedded portion and an exposed portion, and wherein said exposed portion extends from said distal end of said outer sheath and comprises a working surface;

a primary conductor adapted to carry ablative energy from an energy source to said flexible electrode, wherein said primary conductor comprises an uninsulated portion in electrical contact with said flexible electrode; and

a flexible boot at said distal end of said outer sheath, said flexible boot defining an annular fluid jacket around a booted portion of said flexible electrode, wherein said booted portion comprises at least a portion of said exposed portion of said flexible electrode, and wherein said annular fluid jacket is adapted to carry fluid that is in fluid communication with said annular channel.

66. The catheter of claim 65, wherein said inner sheath further comprises a lumen adapted to carry fluid, and wherein said mechanical interface is porous.

67. The catheter of claim 65, wherein said flexible electrode comprises a plurality of filaments defining a brush electrode having interstitial gaps between said filaments, wherein said interstitial gaps are adapted to direct fluid toward said working surface.

68. The catheter of claim 67, wherein said brush electrodes comprises a conductive core.

69. The catheter of claim 68, wherein said conductive core is circumscribed by nonconductive filaments.

70. The catheter of claim 67, wherein said brush electrodes comprises a nonconductive core.

71. The catheter of claim 70, wherein said nonconductive core is circumscribed by conductive filaments.

72. The catheter of claim 65, wherein said flexible boot is porous.

73. The catheter of claim 65, wherein said uninsulated portion of said primary conductor is looped around said booted portion of said flexible electrode.

74. The catheter of claim 65, wherein said uninsulated portion of said primary conductor is looped around a portion of said conforming electrode that is present in at least one of said annular channel and said annular fluid jacket.

75. The catheter of claim 65, wherein said outer sheath circumscribes said inner sheath, forming said annular channel between said inner sheath and said outer sheath, and wherein said annular channel is adapted to introduce fluid to said booted portion of said flexible electrode.

76. The catheter of claim 65, wherein said catheter further comprises a smooth outer wall covering said outer sheath.

77. The catheter of claim 65 further comprising an annular layer of porous material within said annular fluid jacket.

78. The catheter of claim 65, wherein said brush electrodes comprises conductive filaments interspersed among nonconductive filaments.

79. The catheter of claim 78, wherein said conductive filaments are grouped in clusters.

80. The catheter of claim 65, wherein said flexible electrode comprises a plurality of hollow filaments.

81. The catheter of claim 80, wherein said plurality of hollow filaments comprises at least one shortened hollow filament that extends part way into said flexible electrode, and wherein said at one shortened hollow filaments is thereby adapted to deliver fluid to an interior region of said flexible electrode.

82. The catheter of claim 65, wherein said flexible electrode comprises a plurality of porous filaments.

83. A method of ablating tissue inside a human body using a flexible brush electrode affixed at a distal end of an outer sheath of a catheter, the method comprising the steps of

placing an exposed portion of the brush electrode adjacent to tissue to be treated;

applying ablative energy to the exposed portion of the brush electrode; and

forming a lesion in the tissue via coagulation necrosis.

84. The method of claim 83, wherein said forming step comprises forming a transmural lesion.